UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
and
Bureau of Agricultural Chemistry and Engineering

EFFECTS OF VARIATIONS IN DESIGN OF GIN-SAW TEETH ON LINT QUALITY AND GINNING EFFICIENCY

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Statement of Cooperation

The seed cottons used in conducting the tests here reported were obtained through cooperation with the following State experiment stations:

Alabama Agricultural Experiment Station, Tennessee Valley Substation, Belle Mina,
Arkansas Agricultural Experiment Station, Cotton Branch, Marianna,
Georgia Coastal Plain Experiment Station, Tifton,
Louisiana Agricultural Experiment Station, Baton Rouge,
Mississippi Agricultural Experiment Station, Delta Branch, Stoneville,
Tennessee Agricultural Experiment Station, West Tennessee Branch, Jackson,

and the following breeders, "increase parties," and growers:

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Wynn Jones, Huntsville; Martingayle Plantation, Shorter; and McQueen Smith Farming Company, Prattville;

Arkansas
Floyd Harbison, Parkdale; Henry H. Naff, Montrose; and Lee Wilson & Company, Wilson;

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E. F. Nunn & Co., Australia Island; and E. B. Saunders, Tallulah;

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EFFECTS OF VARIATIONS IN DESIGN OF GIN-SAW TEETH ON LINT QUALITY AND GINNING EFFICIENCY

By William J. Martin, associate cotton technologist, Agricultural Marketing Service, and Victor L. Stedronsky, assistant mechanical engineer, Bureau of Agricultural Chemistry and Engineering 1/

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1/ The cotton-quality phases of this report are a part of the program of cotton quality and standardization research under the leadership of R. W. Webb, principal cotton technologist, Agricultural Marketing Service. Credit is due to Francis L. Gerdes, cotton technologist, Agricultural Marketing Service, and Charles A. Bennett, senior mechanical engineer, Bureau of Agricultural Chemistry and Engineering, for supervision and suggestions, and to coworkers in both agencies for their assistance.

INTRODUCTION

When lint cotton is damaged in the ginning process, this damage is generally traceable to a damp or wet condition of the seed cotton or to the use of a dense seed roll 2/.

If cotton is too damp to provide good ginning results, it can be dried naturally or artificially; and any of several corrective measures can be employed to decrease the seed-roll density. These measures involve slower feeding of cotton to the gin stands, and the reconditioning and readjustment of those parts of the gin stands that hinder the attainment of normal capacity (4) (17). Even though the rate of ginning may be somewhat increased by making needed improvements in the condition of the gin machinery, a capacity above normal in all gins of good mechanical condition is usually attained by increasing the feeding rate of cotton to them, but this means the use of seed rolls which are too dense to permit smooth ginning.

To discover some means of increasing capacity with standard commercial gin machinery, without the damaging effects of fast ginning, the U. S. Department of Agriculture conducted a series of studies of saw-gin design, at its cotton ginning laboratories.

As the saw tooth itself is the means for separating the fibers from the seed during ginning, it is reasonable to expect that any study of the factors involved in ginning capacity should take into consideration the elements of saw-tooth design. A search of the literature failed to disclose any extensive investigations of this type (14).

Eli Whitney stated in his original affidavits that the point of the wire tooth should pass through the ribs after the base of the tooth, whereas today some designers claim that the point of the saw tooth should pass through the ribs first (2). Some of these designs of saws are in use, but most gin-saw teeth are so constructed that the tooth point and throat both enter the ribs at about the same time. In other words, the pitch line or leading edge of the tooth is approximately parallel to the face of the gin rib as it passes through.

PURPOSE OF THE STUDIES

The objectives of these studies were (1) to determine the effects of variations in saw tooth fineness, pitch, and shape on the quality and value of the ginned product and on the ginning capacity and other mechanical operating elements of the gin, and (2) to ascertain comparative durabilities of different designs of saw teeth.

GIN-SAW CONSTRUCTION

Gin saws of modern huller gins are 12 inches in diameter, but in the past some of the plain gins were equipped with saws that were 10 inches in diameter. Only 9 percent of the gin stands operated in the

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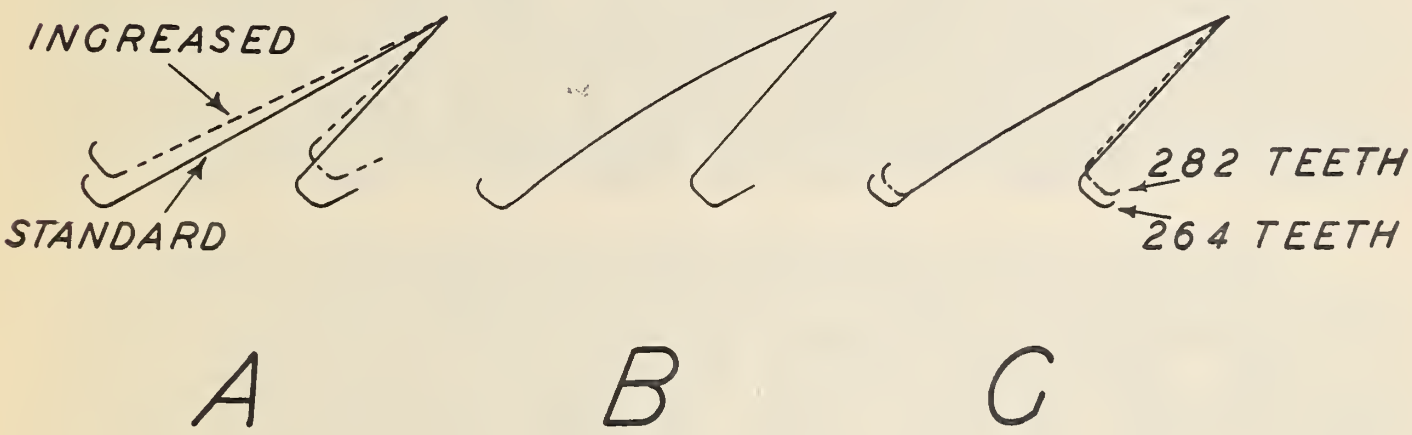
2/ Underlined numbers in parentheses refer to Literature Cited, pp. 24-25. In connection with this opening statement of the text see (3) (6) (9) (15) (16)

United States in 1935 were of 10-inch saw type, and 80 percent of these gins were in the Southeastern States 3/. Commercial practice is to provide from 235 to 255 teeth per 10-inch saw and 264 to 290 teeth per 12-inch saw. The equivalent number of teeth per 12-inch saw is referred to in the ginning industry as "fineness." Pitch refers to the slope of the leading edge of the tooth; and the terms "roached" and "straight" refer to the shape of the trailing edge, or back, of the tooth, as shown in figure 1. The "face" or leading edge of the saw tooth is always

FIGURE 1.—General features of gin-saw teeth with respect to pitch angle, length, and shapes: A, straight; B, heavy roach, and C, modified roach.



straight, regardless of the shape of the back. The straight tooth, shown as A in figure 1, appears to have been universally used until the advent of the double-rib huller gin in 1889, since which time roached teeth have been brought into use (4). This may have been due to a

3/ Bureau of the Census report, "Cotton Ginning Machinery and Equipment by States, 1935." (Mimeographed)

belief that the roach teeth are stronger and more suitable for huller gins. In plain gins, the only function of the teeth is to remove the fiber from the seed; but in huller gins, the teeth also carry the locks of seed cotton from the outer breast into the seed roll. The heavily roached tooth has practically gone out of use, giving way to the modified type shown in C of figure 1. Variations in size of saw teeth due to changes in fineness are given in this illustration.

EXPERIMENTAL PROCEDURE

Preliminary studies of tooth fineness, using a 20-saw plain gin having 10-inch saws, were made during the season of 1933 in an effort to establish the test limits of fineness to be employed in a similar study with a 70-saw commercial huller gin having 12-inch saws. Roach-toothed saws of finenesses ranging from 228 to 282 teeth per saw, by intervals of 18 teeth, were subjected to limited tests on the larger gin in 1934. During that year, indications of the effects of varying the pitch and shape of saw teeth were obtained with a 16-saw plain gin having 10-inch saws, to provide information basic to the planning of tests on a commercial-type gin. With cotton from the 1935 crop, fineness tests on the commercial-size gin were continued, saws of 300 and 318 teeth per saw being added to those studied the previous year. Pitch variations involving increases of 3½ degrees and 7 degrees in pitch angle were also studied in this gin, along with extensive investigations of ginning performance as affected by the use of straight instead of roached teeth. These studies of tooth fineness, pitch, and shape were continued during the 1936 season and involved 3 finenesses, 2 pitches, and 2 shapes of teeth, and their various combinations.

The different saw cylinders used in the saw-tooth experiments herein reported were of the 70-saw, 12-inch-diameter type, and were interchangeable on the gin stand, which was of the double-rib huller brush type. Before being ginned, the seed cotton was handled by only a separator and a cleaning feeder. These units, together with gin saws and brushes, were operated at a constant speed throughout each experiment. The saw cylinder having 264 roached teeth of standard pitch was used as the "control" or basic cylinder. Loose seed rolls were employed in ginning each lot. Uniform density of the seed roll was maintained by the operator observing the height and "feel" of the roll and adjusting the rate of feed of the cotton into the gin stand for each ginning set-up (3). After completion of the test with each set-up, the saw cylinder was removed, and the succeeding one was put in its place for testing. Care was exercised so that all relationships (such as those of saws to huller ribs, to roll box, to brush, and so forth) were identical during each test. During the performance of each test, engineering observations and records were made, and samples were taken in accordance with standard procedure and reserved for laboratory analyses and classification (3) (6).

Observations of certain comparative durability qualities of the control type of saw and the saws varying in many of the tooth-design features tested, were made at commercial gins during the ginning seasons of 1936, 1937, and 1938. At each of 11 gins, a control saw cylinder was operated in a gin stand adjacent to one operating with a saw cylinder of a specific variation in tooth type. That is, the performance and condition of each of 11 cylinders differing in tooth design are periodically recorded along with similar observations of the corresponding control saw cylinder.

Concurrently with the making of the saw-durability tests over a 3-year period, extensive laboratory tests of the performance of both straight and roached saws of 264 and 282 teeth per saw were made after reducing them one-thirty second and one-sixteenth of an inch in diameter by multiple sharpenings. Also, during the 1938 season, similar tests were made with straight- and roached-back saws (264 teeth per saw) that were reduced in diameter to the same extent but caused by ginning service and periodic sharpenings.

A total of 97 lots of cotton were used in the studies of gin-saw teeth here reported, and represent 3 crop years - 1934, 1935, and 1936. From the crops of 1936, 1937, and 1938 samples of lots of 81 cottons were used to study the effects of sharpening and reducing the diameter of saws having different designs of teeth. The cottons for each of the two series of studies were secured from 9 States through cooperation with experiment stations and cotton breeders, "increase parties," and growers. Through these mediums, it was possible to cover the wide range of conditions and qualities desired; and all picking and handling was performed either under the supervision of, or in accordance with instructions from, a representative of the ginning laboratories.

The samples resulting from the experiments were classed and subjected to fiber analyses according to procedure adopted by the fiber laboratories of the Agricultural Marketing Service and reported in previous publications (3) (5) (6) (7). In the laboratory, brilliance and chroma readings (11) (12) (13), moisture tests (1), and fiber length arrays (1) (18) were made of samples ginned with each of the saw tooth set-ups. Original classifications of all of the samples were made by a Government classer without knowledge of the ginning conditions employed, and check classifications of 40 percent of the samples from the tests were furnished independently by other classers of the Department of Agriculture.

The discussions of the results of studies of saw teeth have been divided into four main groups, in accordance with the variations - tooth fineness, tooth pitch, tooth shape, and combinations of these. It is realized that other modifications are possible but they are beyond the scope of this study. It should be recognized, however, that there are attendant variations which must occur in conjunction with those by which these tests are identified. With variations in tooth fineness, there are

associated changes in the size of the teeth and in the openings between them. Increasing the pitch angle of the saw tooth will change the relationship of the teeth to the seed roll and the ribs of the gin. Effects of these and other variations that are an outgrowth of the major differences should be considered as included in the effects attributed to the specified changes in tooth design.

In the analysis of the data obtained through each series of tests, the cottons were grouped only by lengths (1-1/8 inches and longer, and shorter than 1-1/8 inches) because other conditions and qualities did not affect the results enough to justify further segregation. For every type of saw tested, averages were made of each quality element, each mechanical element, and the monetary value obtained with each group of cottons. Differences between the averages for the control saw and those for each of the other saws were calculated and degrees of significance were determined for these values using Student's Method and probability table for ascertaining the significance of differences between paired observations (10). Odds within the range of 19 to 1 and 99 to 1 are considered significant and are denoted by one asterisk (*) accompanying the difference figures presented in succeeding charts. Odds above 99 to 1 are considered highly significant and are denoted by two accompanying asterisks (**).

The averages for grade were based on summations of the numerical code values 4/ of color, leaf, and preparation; and those for staple length, on values for designations in intervals of one-thirty second of an inch. The averages for bale weights were calculated on the basis of percentage turnout of lint from seed cotton plus 22 pounds tare for bagging and ties. Ginning time and energy consumption are for the gin stand while ginning 1,500 pounds of seed cotton. Energy consumption per bale is in terms of kilowatt-hours calculated from figures of power requirements and ginning time by the formula, $\frac{\text{HP} \times .746 \times \text{Time (in minutes)}}{60}$.

Value per bale was calculated by applying to the grades and staples for each set-up the approximate average prices for the specified White grades and staple lengths prevailing at Memphis, Tenn., for the seasons 1932-33, 1933-34, 1934-35, and 1935-36 and multiplying by the bale weight (3) (8).

RESULTS AND OBSERVATIONS

Considerable laboratory investigation was done on all four phases of the problem prior to the performance of the tests here reported. Many modifications were made but some were discarded while the practical limits were being established. The more pertinent results of the study are herein presented. All comparisons are in terms of variations in tooth types from that of the 264 roached teeth of the control saws. The results were segregated by quality according to staple length only; and

4/ 1.0 point equals one grade step.

they are presented in two groups—the longer and shorter staples, because preliminary computations indicated that variations in moisture content, foreign matter, and other conditions and qualities of the seed cotton showed little if any influence on the relationships involved.

Effects of Variations in Fineness of Saw Teeth

Variations made in saw-tooth fineness from that of 264 teeth per saw generally affected ginning time, energy consumption of the gin stand, bale weight, and value of the lint (figs. 2 and 3).

Ginning Time, Power Requirements, and Energy Consumption

Increases in tooth fineness from 264 teeth up to 300 teeth per saw reduced the ginning time, the savings amounting to as much as 8 percent on both the longer and the shorter cottons (fig. 2). Finer teeth, 318 per saw, showed no advantage from this standpoint over the standard 264, whereas the coarser teeth, 246 per saw, gave excessive increases in ginning time that approximated an average of 28 percent in the case of the shorter cottons. This is no doubt due to the fact that, within certain limits, regardless of size, each tooth has a similar capacity for carrying lint out of the roll box. Since the quantity of lint removed per tooth is about the same for the saws of 246 and 264 teeth, slower ginning results from the coarser toothed saw, but up to a certain limit of fineness, more teeth remove more cotton and greater capacity results. Beyond this limit, the teeth of greater fineness become so small that they do not penetrate the seed roll as much, nor carry the optimum quantity of lint, and the capacity begins to show a decline, as is the case with the 318 tooth-saw.

With the use of saws coarser than 264 teeth, the power required by the gin stand was reduced, and with the use of the finer saws there was a slight but insignificant increase. As a result of the improvements in ginning capacity, the finer toothed saws effected savings in energy consumption, ranging up to 5 percent with the longer and 8 percent with the shorter cottons ginned by the saws of 300 teeth. It should be borne in mind that these savings in ginning time and energy consumption refer to the gin stand only, and would be greater if all the auxiliary equipment involved in a commercial gin were considered, because fans, cleaners, distributors, etc., must necessarily be operated until all the cotton is ginned; and decreases in ginning time are naturally reflected in lower energy consumption. If a gin outfit, exclusive of the press requirements, consumes an average of 10 kilowatt-hours for ginning a bale of cotton with saws of the control type of teeth; and it gins 2,000 bales during the season, or consumes a total of 20,000 kilowatt-hours of energy, savings of 5 to 8 percent in energy consumption by the use of finer-toothed saws would reduce the energy 1,000 to 1,600 kilowatt-hours, or cause monetary savings on power conservatively estimated at $25 to $50 for the season.

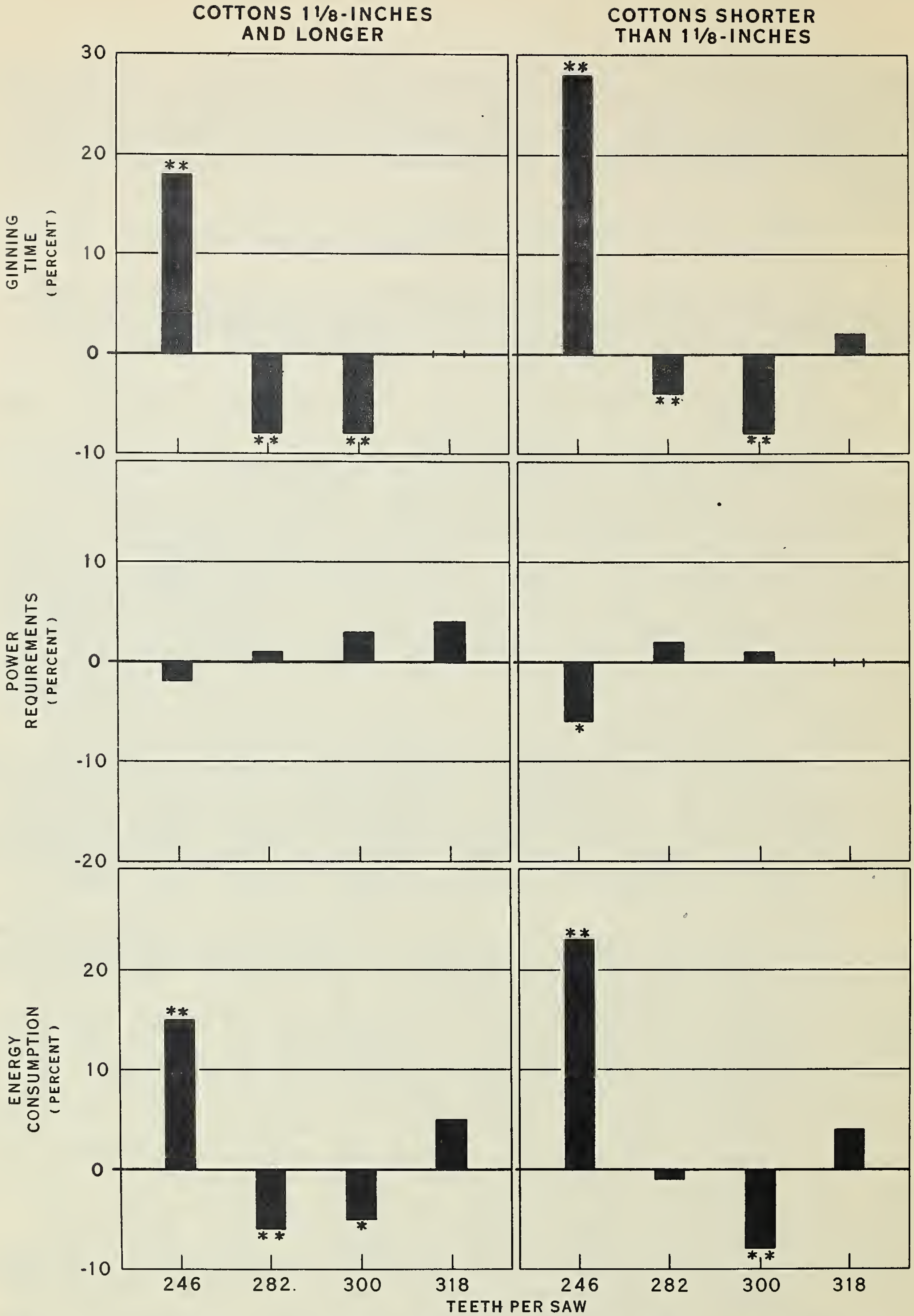


FIGURE 2. — Average of the differences in ginning time, power requirements, and energy consumption between the control saw (264 tooth fineness) and saws of specified finenesses. Significant differences are denoted by one asterisk (*), and highly significant differences by two asterisks (**).

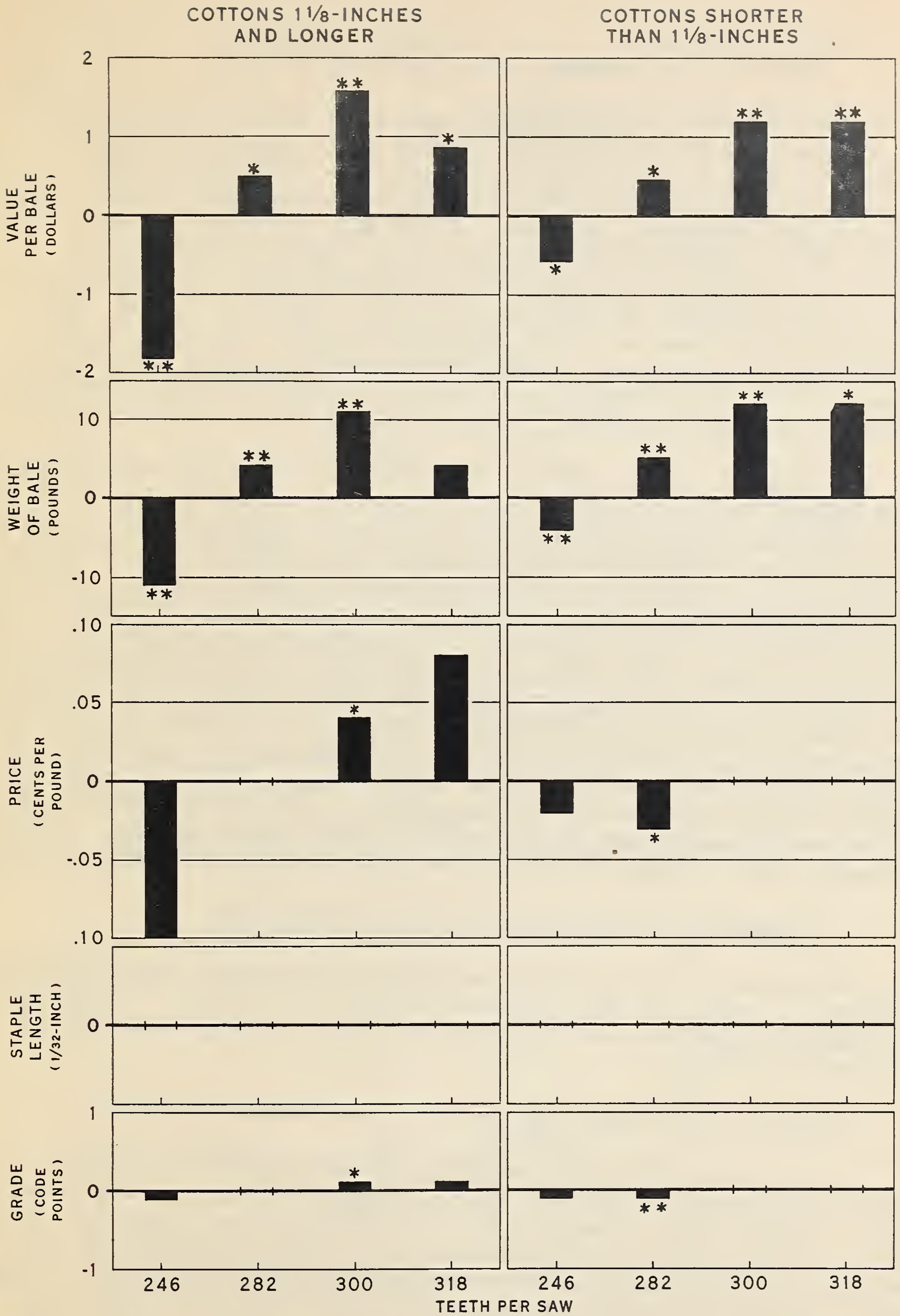


FIGURE 3. — Average of the differences in bale value, weight, price, staple length, and grade between the control saw (264 tooth fineness) and saws of specified finenesses. Significant differences are denoted by one asterisk (*), and highly significant differences by two asterisks (**).

Quality, Bale Weight, and Value of the Lint

The differences in the grade of the lint associated with variations in saw-tooth fineness are generally small and inconsistent (fig. 3). No effects on the staple length were indicated by the classifications, but because of producing increased fiber length variability in many instances, the saws of 300 and 318 teeth per saw naturally had a slight tendency to lower the average or mean fiber length, as measured in the laboratory. This increased variability resulted from the removal of more of the shorter fibers from the seed when ginning with these saws than when ginning with the control saws, as illustrated in figure 4. The additional fibers ranged in length from about 13/16 inch downward to 1/16 inch or shorter; and, therefore, represented some usable fibers, particularly with the shorter cottons.

The addition of the shorter length fiber to the lint is reflected in bale weight to the extent of about 4 pounds with the 282-tooth saws and 11 pounds with the 300-tooth saws (fig. 3). The increases shown for the 318-tooth saw were not so significant. Reduction in saw fineness from that of the control saw caused decreases in lint turnout. With increased fineness, more teeth are coming in contact with the seed in passing through the seed roll which is revolving at approximately a constant rate of speed. This affords a relatively better opportunity to remove more lint up to the point where the teeth become fully loaded, as in the case of the saws of 300 teeth. Taking into account the differences in bale weight caused by variations in closeness of ginning and the price differences resulting from grade changes, the bale value of the lint of the longer cotton was enhanced 49 cents by the 282-tooth saw, $1.57 by the 300-tooth saw, and 86 cents by the 318-tooth saw. Value improvements very similar to these were indicated for the shorter cottons.

Effects of Variations in Pitch of Saw Teeth

Increasing the pitch angle of the gin-saw teeth, like increasing the number of teeth per saw, produced changes principally in ginning time, energy consumption of the gin stand, bale weight, and value of the lint (figs. 5 and 6).

Ginning Time, Power Requirements, and Energy Consumption

By increasing the pitch angle of the saw teeth, the ginning capacity was improved (fig. 5). On the longer cotton, ginning time was reduced 8 percent and 13 percent by the use of the two respective increases in tooth pitch, and on the shorter cotton, 6 percent by each. Increasing the pitch angle causes the leading edge of the tooth to lean forward, changing the angle of penetration into the seed roll. This decreases the angle of incidence of the fibers against the face of the tooth and increases the component force of the fibers down to the tooth. Hence the teeth tend to load up more completely and remove more lint per passage through the roll box.

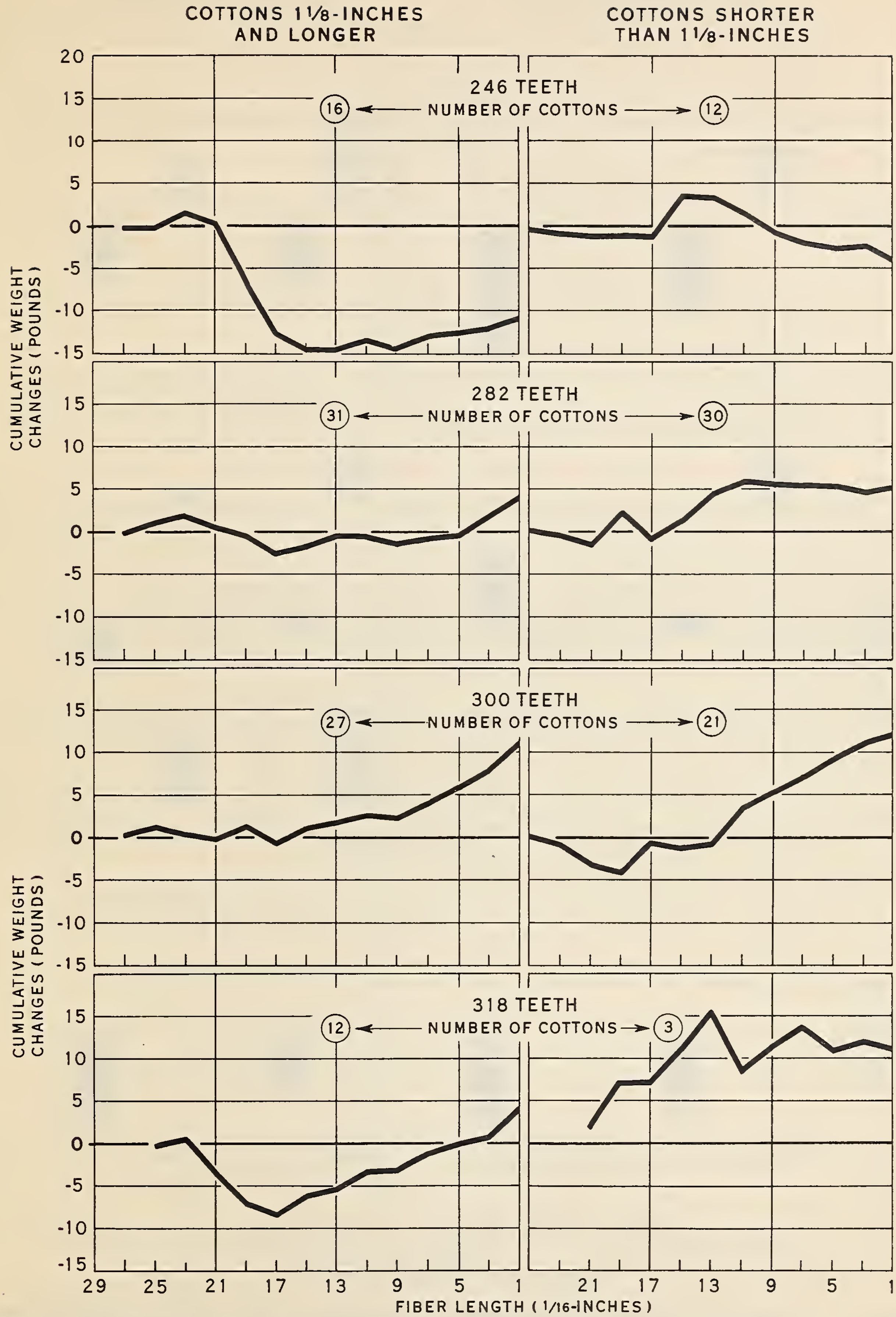


FIGURE 4. — Average of the differences between the control saw (264 tooth fineness) and saws of specified finenesses with respect to cumulative weights of fibers of different length intervals in the lint ginned from 1,500 pounds of seed cotton.

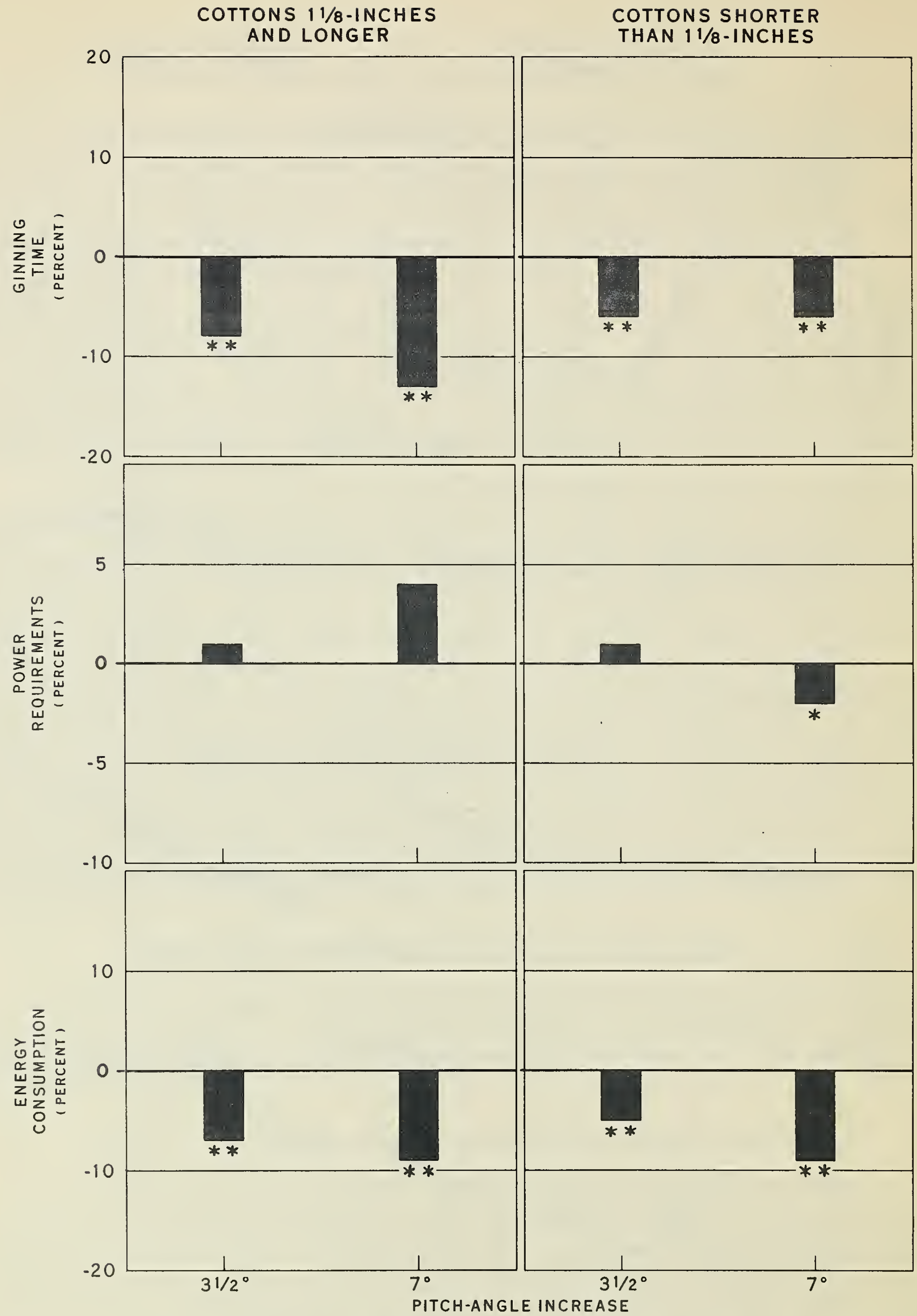


FIGURE 5. — Average of the differences in ginning time, power requirements, and energy consumption between the control saw (standard pitch angle) and saws of specified pitch angle increases. Significant differences are denoted by one asterisk (*), and highly significant differences by two asterisks (**).

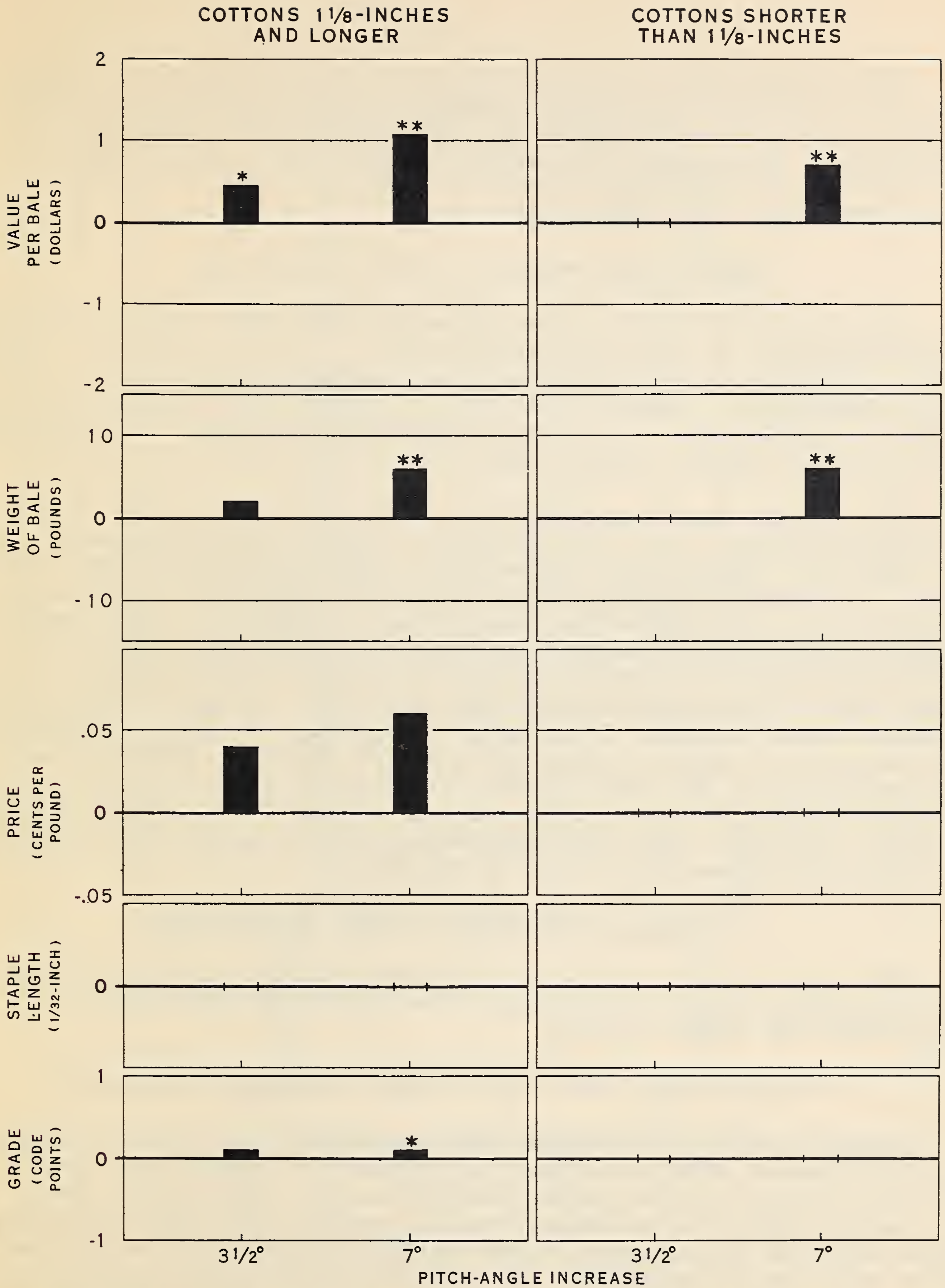


FIGURE 6. — Average of the difference in bale value, weight, price, staple length, and grade between the control saw (standard pitch angle) and saws of specified pitch angle increases. Significant differences are denoted by one asterisk (*), and highly significant differences by two asterisks (**).

Power requirements of the gin stand were not influenced to a great extent, but economies in energy consumption traceable to savings in ginning time resulted from increasing the pitch angle of the saw teeth, averaging about 6 percent with the smaller increase and 9 percent with the larger increase in pitch angle. These benefits, in terms of a season's ginning operations, are substantial.

Quality, Bale Weight, and Value of the Lint

Increases in the pitch angle of the saw teeth were seldom accompanied by improvements in the grade and staple length of the lint (fig. 6). However, adverse differences in variability of fiber length were sufficient to cause the mean length to be reduced by the use of the saws with the teeth increased 7 degrees in pitch angle. As shown in figure 7, this higher variability was due to fibers of shorter lengths being added to the lint during ginning.

Bale weight was not affected by increasing the pitch angle of the saw teeth 3½ degrees, but it was increased 6 pounds by the increase of 7 degrees (fig. 6). Although there seems to be some relationship between fast ginning and additional turnout, the increase of 3½ degrees in pitch angle appears to have accomplished the former without the latter. The 7-degree increase in pitch gives a sharper penetration into the seed roll, and this increased acuteness, like that of a sharp to a blunt chisel, results in slightly more effective operation, which aggregates a significantly additional turnout during ginning. It is further reasonable to expect a slightly improved seizure of fibers by the tooth with sufficiently increased pitch. Owing principally to increased turnout, the bale value of the longer cotton was enhanced $1.07, and that of the shorter cotton, 70 cents, by increasing the pitch 7 degrees. Bale value improvements of the longer cotton amounted to 45 cents by increasing the pitch 3½ degrees.

Effects of Variations in Shape of Saw Teeth

The shape of the trailing edge of saw teeth has a marked effect on the ginning time, energy consumption of the gin stand, bale weight, and value of the lint (figs. 8 and 9).

Ginning Time, Power Requirements, and Energy Consumption

Ginning capacity of straight teeth was better than that of roached teeth by 8 percent with the cottons 1-1/8 inches and longer, and 6 percent with the cottons of shorter staple length (fig. 8). This type of tooth has a larger opening to the throat than the roached tooth and consequently permits more lint to be carried by the tooth and allows it to be shed more readily each time it passes from the roll box, which condition increases the ginning capacity. Differences in ginning time were responsible for the economies effected in energy consumption of the gin stand, which amounted to 5 percent for the straight teeth on both groups of cottons. Power requirements were increased slightly and significantly by the use of saws having straight teeth in ginning the longer staple cottons.

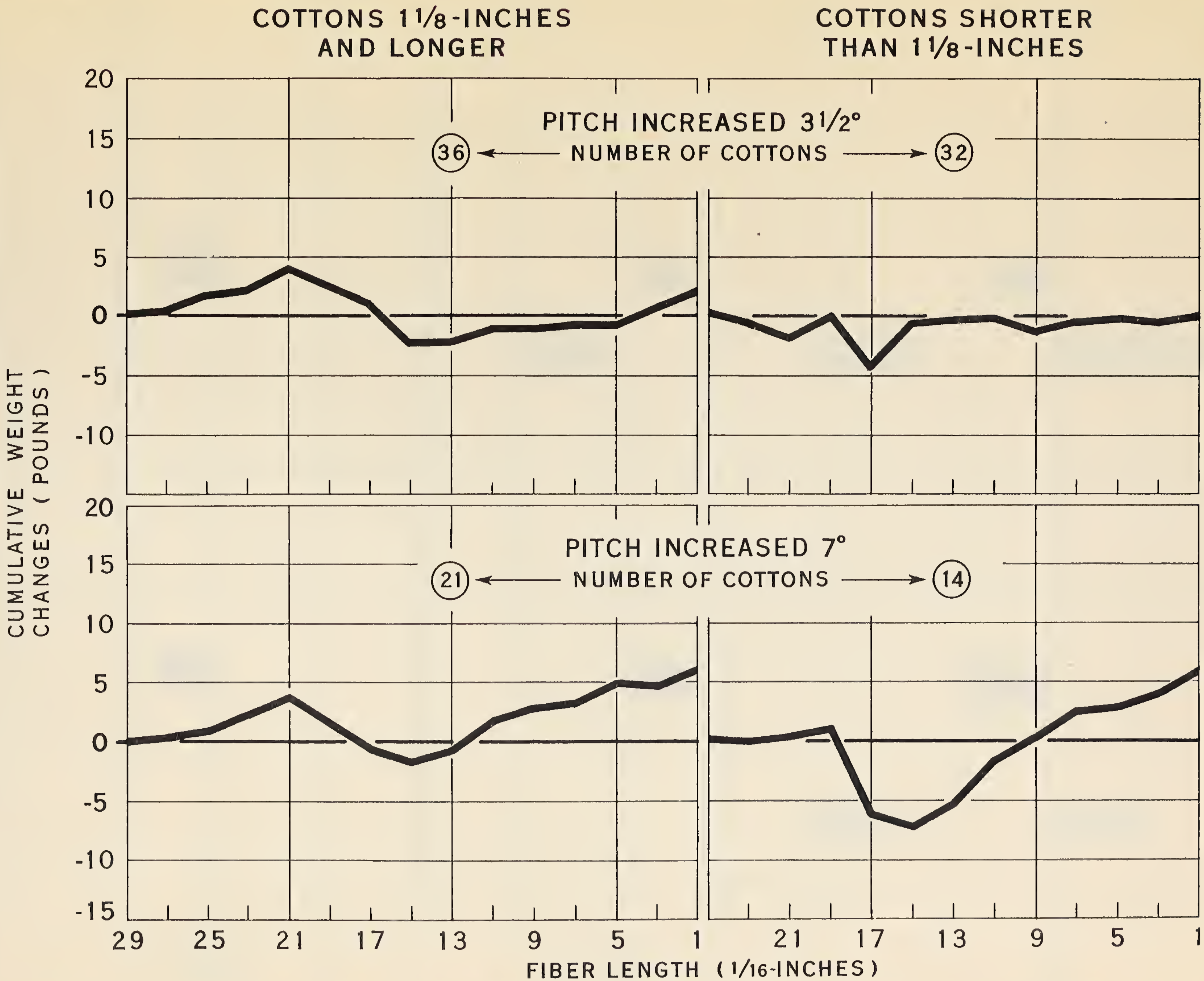


FIGURE 7. — Average of the differences between the control saw (standard pitch angle) and saws of specified pitch-angle increases with respect to cumulative weights of fibers of different length intervals in the lint ginned from 1,500 pounds of seed cotton.

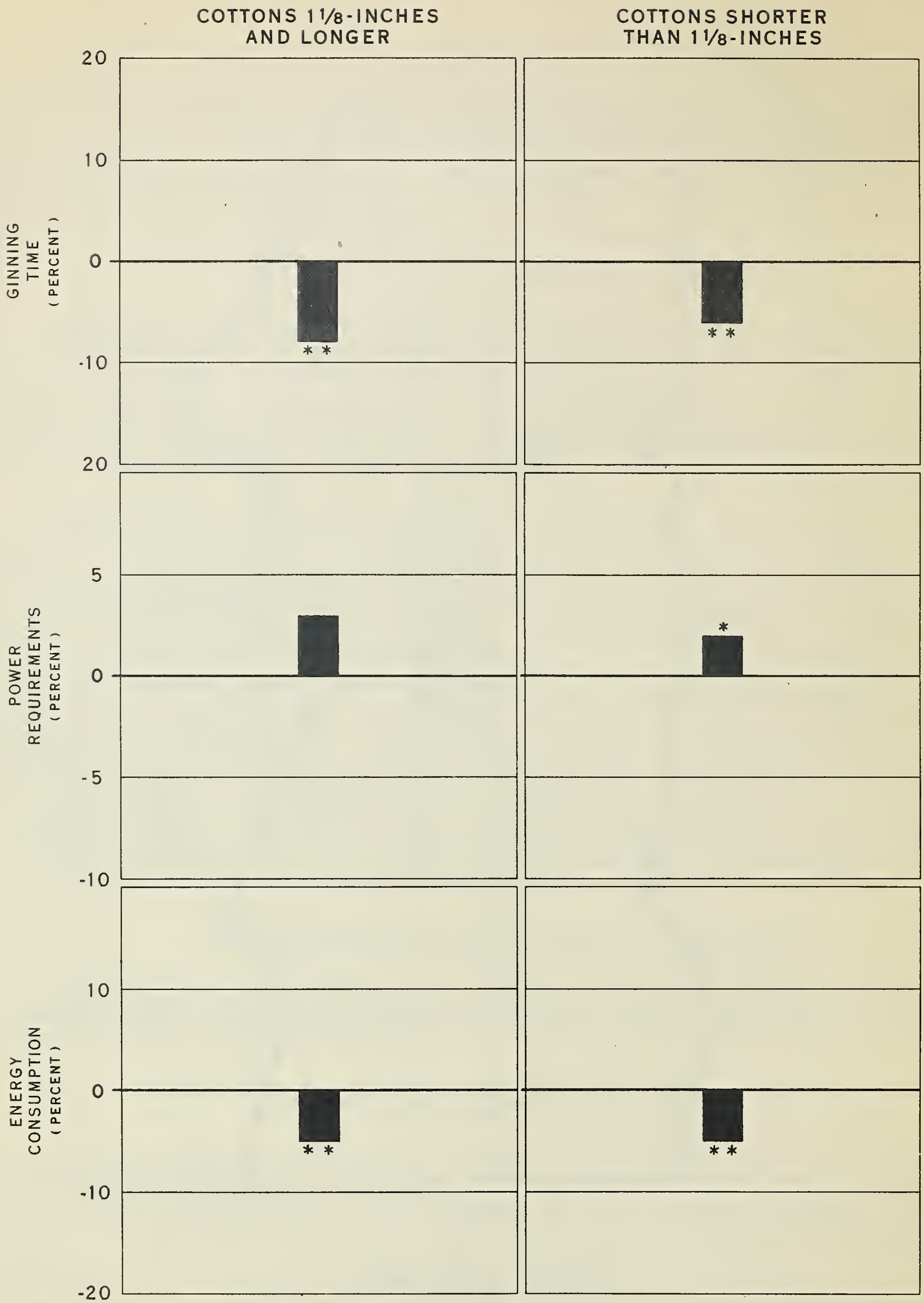


FIGURE 8. — Average of the differences in ginning time, power requirements, and energy consumption between the control saw (roached teeth) and a saw of straight teeth. Significant differences are denoted by one asterisk (*), and highly significant differences by two asterisks (**).

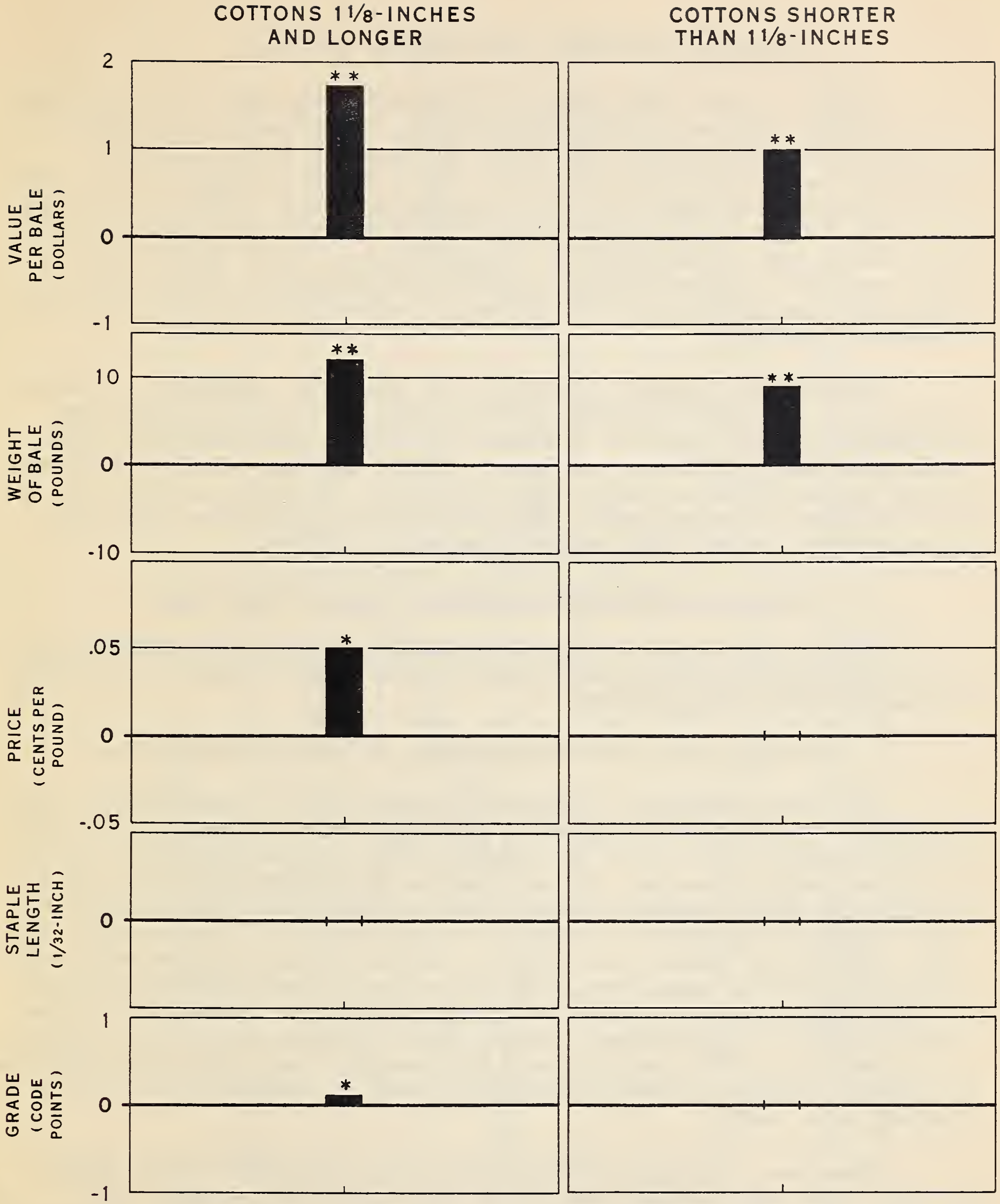


FIGURE 9. — Average of the differences in bale value, weight, price, staple length, and grade between the control saw (roached teeth) and a saw of straight teeth. Significant differences are denoted by one asterisk (*), and highly significant differences by two asterisks (**).

Quality, Bale Weight, and Value of the Lint

As was the case when ginning with saws having teeth finer than the 264 tooth saw, the use of straight teeth did not influence the grade of the ginned lint appreciably and showed no change in staple length as designated in classification (fig. 9). The mean fiber length of the samples ginned with straight teeth was slightly and consistently shorter than that of the samples ginned with roached teeth because the length uniformity of the fibers was disturbed by the addition of fibers shorter than 13/16 inch to the ginned lint(fig. 10). This shortening of the mean fiber length was more pronounced with the longer cottons which showed a greater increase in turnout.

Bale-weight increases caused by the increased percentage of shorter length fiber averaged 12 pounds for the longer cotton and 9 pounds for the shorter cotton (fig. 9). A slight increase in price resulting from small grade improvements on the longer cotton, together with the additional lint ginned by the straight teeth, caused a bale-value increase of $1.73 in favor of these teeth. With the shorter cotton, the bale-value increase due to higher bale weight amounted to only $1.

Effects of Other Variations in Design of Saw Teeth

When combinations of some of the tooth features that enhanced ginning capacity were made to see if still better capacity would be attained, the results were disappointing.

Ginning Time, Power Requirements, and Energy Consumption

From the standpoint of affecting ginning time, no saw having a combination of the different departures in design from the control saw showed an advantage over any of the saws varying from the control in only one of the three design elements. In fact, the saw having 282 straight teeth was the only one that compared favorably with the saws whose tooth construction involved a variation in only one of the factors of tooth design. The other saws showed smaller increases in ginning capacity. Power requirement effects with all of these saws, like those for the saws discussed earlier in this report, were so small that energy-consumption figures were influenced largely by ginning-time results; and, therefore, with the exception of the saw having 282 straight teeth and possibly two others, the economies in energy consumption from the departures made in combination of tooth features were small.

Nisengauz, Kokotkin and Topol'skaia (14) concluded from a series of tests made with 10-inch saws having 235 roached and straight teeth that shape of the tooth had no effect on ginning capacity. The fineness of this saw is equivalent to a 12-inch saw having 282 teeth. By comparing the effects on ginning capacity of the 282 roached teeth with the 282 straight, it was learned that the latter improved ginning capacity only 2 percent more than the former, and thus the results of the two independent investigations are not altogether divergent. As shown before,

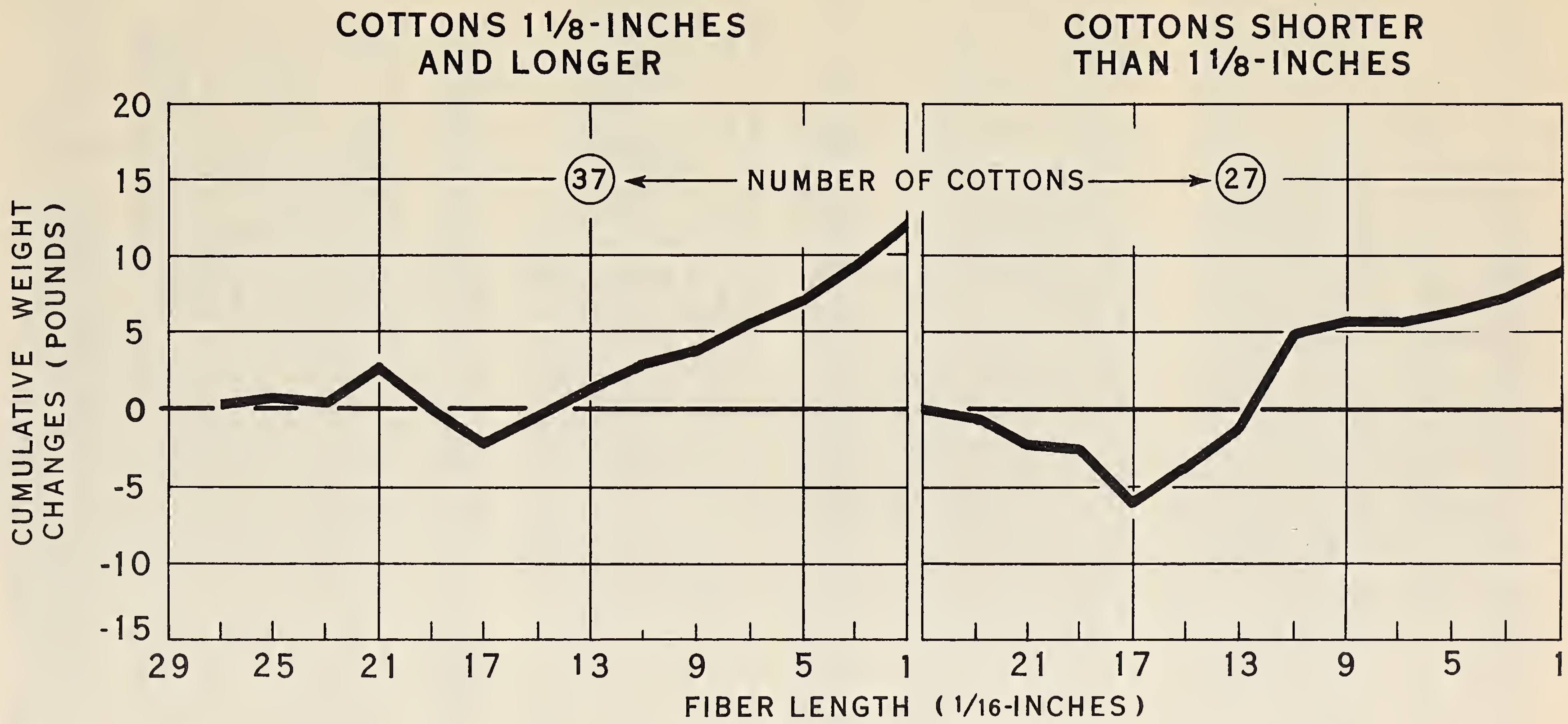


FIGURE 10.— Average of the differences between the control saw (roached teeth) and a saw of straight teeth with respect to cumulative weights of fibers of different length intervals in the lint ginned from 1,500 pounds of seed cotton.

however, ginning capacity was definitely benefited by the use of straight teeth in place of roached teeth on saws of 264 teeth.

Quality, Bale Weight, and Value of the Lint

Reductions in mean fiber length were associated with the ginnings made with the saws having 282 straight teeth; and, as in previous tests of teeth that increased lint turnout, they result from the addition of about 13 pounds of fibers that are 1 inch and shorter in length to the lint ginned from 1,500 pounds of longer staple seed cotton, and of a substantial quantity of fibrous material of varying lengths below 11/16 inch to the shorter staple cotton.

As a result of the variability in turnout for the saws of different combinations of departures in tooth design, bale differences showed wide variations in different directions. Bale-value benefits, similar to those secured with the saws having 264 straight teeth of standard pitch, were evident with the 282 straight teeth of standard pitch, and the 264 straight teeth of increased pitch. On the other hand, losses of various small and insignificant quantities with the more elaborate combinations of tooth design features were indicated 5/.

Effects of Variations in Design of Saw Teeth on Their Damage During Field Operation of Commercial Gins

Saw cylinders with teeth of the various types were installed in commercial gins and operated during the seasons of 1936, 1937 and 1938. Periodic counts were made on the control saws (264 roached teeth of standard pitch) and the other saws varying as to pitch, shape and fineness, and showed very little difference in the wearing properties of the teeth of different designs. The 264 straight teeth of increased pitch, the 282 straight teeth, and the 300 straight teeth were the only ones showing a tendency to be less resistant to wear.

Effects of Variations in Design of Saw Teeth on Performance of Saws After Sharpening and Reducing to Smaller Diameters

In the laboratory, roached and straight teeth, numbering 264 and 282 teeth per saw, were subjected to multiple sharpening with both rotary and triangular saw-filing machines and reduced in diameter by one-thirty second of an inch by an average of eight sharpenings. An effort was made to preserve the pitch of these saw teeth during the sharpening operations. The reductions made in saw diameters caused appreciable losses in ginning capacity and lint turnout even when readjustments of breast and saw positions were made. When new saw capacity was maintained with the smaller saws, the seed roll became more dense, and the

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5/ The reader interested in more detailed results of these tests and those discussed in succeeding pages is referred to the U. S. Cotton Ginning Laboratories, Stoneville, Miss.

grade of the cotton was lowered. The effects on grade and turnout of the saw reduced one-sixteenth of an inch in diameter caused bale-value losses that averaged as much as $2 per bale when sharpening the straight teeth with rotary side files. The smaller reductions made in saw diameter produced effects similar to these. The losses in lint-turnout associated with reduction in saw diameter were greater with straight than with roached teeth because with continuous sharpening the latter tended to assume a straighter shape which proved to give better turnout than roached teeth in the investigations previously discussed. Moreover, from this standpoint, the triangular filing showed slightly better results than the rotary side filing because it produced a straighter tooth and one with better carrying capacity.

Saws were obtained from commercial gins for testing after being reduced in diameter one-thirty second and one-sixteenth of an inch by sharpening and wear. They represented roached and straight designs with 264 teeth per saw. As was found with saws reduced in diameter in the laboratory by sharpening only, these field-worn saws gave lower turnout than new 12-inch saws, wear and sharpening producing greater losses with the straight teeth than with the roached teeth. However, these saws did not lower ginning capacity as much as the laboratory sharpened saw. Investigations disclosed that this difference in performance was attributable, in part, to the fact that the pitch angle of the teeth of these saws was increased during field sharpening while that of the laboratory sharpened saws was held to standard.

SUMMARY

Ginning experiments previously made and reported upon, reveal that loose-seed-roll ginning provides better quality lint than tight-seed-roll ginning, but at a sacrifice of ginning capacity; and observations in commercial gins indicate that a substantial portion of the crop is ginned with seed rolls of too much density as a consequence of feeding cotton too rapidly to the gin.

In an effort to obtain desirable capacity and yet employ loose seed rolls in ginning, the U. S. Department of Agriculture inaugurated a series of saw-gin-design studies which involve, among other things, the study of the ginning performance of saws having various designs of gin-saw teeth. Using the saw of 264 teeth shaped with a modified roach back as the control saw, saws representing departures from it in fineness, pitch, and shape and in their combinations were studied with respect to their effects on ginning capacity, lint turnout, power requirements and energy consumption of the gin stand, and quality, and value of the ginned lint. These studies involved the ginning of 97 cottons from the crops of 1934, 1935 and 1936, records and observations during ginning, fiber analyses and classification of the samples, compilation and statistical analysis of the results, and field durability tests of the saws. Also included was a study of the ginning performance, after multiple sharpenings, of saws having roached and straight teeth numbering 264 and 282 per saw.

The effects on gin-operating elements and on lint quality of the modified desings of teeth are based on the averages of paired differences in these factors between the control saw and each of the other saws for cottons grouped as 1-1/8 inches and longer, and shorter than 1-1/8 inches.

The tests revealed that ginning capacity with existing designs of gins can be improved by making reasonable increases in the number of roached teeth on saws, by moderately increasing the pitch of these teeth, or by changing the roach-backed shape of the teeth to a straight-back design. Compared with the 264 roached teeth of the control saw, increases in fineness of the teeth up to 300 teeth per saw resulted in savings in ginning time that averaged about 8 percent, for cotton 1-1/8 inches and longer and for cotton shorter than 1-1/8 inches in staple length. The finer saw (318 teeth per saw) showed no advantage from this standpoint over the control saw. By increasing the pitch angle of the saw teeth $3\frac{1}{2}$ degrees and 7 degrees, the ginning capacity was improved 8 percent and 13 percent, respectively, on the longer cottons and 6 percent in both instances on the shorter cottons. Ginning capacity of straight teeth was better than that of roached teeth by 8 percent on the longer cottons and 6 percent on the shorter cottons.

From the standpoint of affecting ginning time, no saw having a combination of the different departures in design from the control saw showed an advantage over any of the saws varying from the control in only one of the three design elements. The saw having 282 straight teeth was the only one that compared favorably with the saws whose tooth construction involved a variation in only one of the factors of tooth design at a time.

With the exception of the $3\frac{1}{2}$-degree increase in saw-tooth pitch, the modifications in tooth design that improved ginning capacity generally increased the lint turnout, or the "closeness" of ginning. On a bale-weight basis, this increased turnout amounted to about 5 pounds with the 282-tooth saw and 12 pounds with the 300-tooth saw on the longer as well as the shorter cottons; 6 pounds with the increase of 7 degrees in saw-tooth pitch on both length groups of cotton; and 12 pounds and 9 pounds when changing from roached to straight teeth on the longer staple and the shorter staple cottons, respectively.

The various departures in tooth design that increased the ginning capacity and the lint turnout showed few significant effects on grade; and although they did not influence the staple length as designated by the classer, the variability of fiber length was increased enough to cause the average or mean fiber length to be slightly less, as measured in the laboratories, particularly when the straight teeth were used. Generally, the additional lint ginned by these teeth ranged from 13/16 inch downward to 1/16 inch in length; and some of it, therefore, would constitute waste in the process of spinning, although the longer fibers should be usable.

Owing to increased turnout and in spite of the fact that it represented some short fiber, bale-value enhancements were shown for the cottons 1-1/8 inches and longer. They averaged 50 cents with the saws having 282 teeth and $1.50 with those having 300 teeth, 45 cents with the $3\frac{1}{2}$-degree increase and $1 with the 7-degree increase in pitch of saw teeth, $1.75 with the 264-straight teeth and $1.65 with the 282-straight teeth. The shorter cottons showed corresponding bale-value betterments that were slightly less than those indicated for the longer cottons, because of the smaller bale-weight increases and the lower prices per pound associated with them.

The changes made in the design of saw-teeth, in general, barely but insignificantly increased the power requirement of the gin stand. In those instances where these saws reduced the ginning time, the power-requirement increases were not sufficient to prevent a showing of substantial economies in energy consumption. In most cases these savings were within a range of 5 to 8 percent; and they are conservatively estimated to bring monetary savings from $25 to $50 on a season's operation of 2,000 bales on a gin outfit.

The wearing properties of the saws of different designs of teeth, as determined periodically in commercial gins over a 3-year period, were about the same as those of the saw with the 264 roached teeth of standard pitch except that the 264 straight teeth of increased pitch, the 282 straight teeth and the 300 straight teeth showed a slight tendency to be less resistant to wear.

The reductions made in saw diameter of one-sixteenth of an inch by wear and sharpening caused appreciable losses in lint turnout in spite of the readjustments made in breast and saw positions. Losses in ginning capacity can be appreciable unless the pitch angle of the teeth is gradually increased without weakening the teeth during periodic sharpenings made of gin saws. Roached teeth give less lint turnout than straight teeth when new; but when the saws are reduced in diameter by several sharpenings, which cause the teeth to assume a straighter back, they do not show as much loss in turnout as that produced by straight teeth similarly sharpened.

LITERATURE CITED

(1) AMERICAN SOCIETY FOR TESTING MATERIALS.
1935. . . . A. S. T. M. STANDARDS ON TEXTILE MATERIALS. Prepared by Committee D-13 on Textile Materials. 246 pp., illus. Philadelphia.

(2) BENNETT, CHARLES A.
1933. EARLY YEARS OF THE COTTON GIN. The Cotton and Cotton Oil News, 34 (13) 5-10, 44.

(3) ________________ AND GERDES, FRANCIS L.
1936. EFFECT OF GIN-SAW SPEED AND SEED-ROLL DENSITY ON QUALITY OF COTTON LINT AND OPERATION OF GIN STANDS. U. S. Dept. Agr. Tech. Bull. 503, 40 pp., illus.

(4) ________________ AND GERDES, FRANCIS L.
1936. CARE AND MAINTENANCE OF COTTON-GIN SAWS AND RIBS. U. S. Dept. Agr. Circ. 393, 20 pp., illus.

(5) BUREAU OF AGRICULTURAL ECONOMICS
1938. THE CLASSIFICATION OF COTTON. U. S. Dept. Agr. Misc. Pub. 310, 54 pp., illus.

(6) GERDES, FRANCIS L. AND BENNETT, CHARLES A.
1936. EFFECT OF ARTIFICIALLY DRYING SEED COTTON BEFORE GINNING ON CERTAIN QUALITY ELEMENTS OF THE LINT AND SEED AND ON THE OPERATION OF THE GIN STAND. U. S. Dept. Agr. Tech. Bull. 508, 62 pp., illus.

(7) ________________ AND JOHNSON, ARVID J. AND BENNETT, CHARLES A.
1938. EFFECT OF CLEANING SEED COTTON ON LINT QUALITY AND GINNING EFFICIENCY. U. S. Dept. Agr. Tech. Bull. 663, 64 pp., illus.

(8) HOWELL, L. D., AND BURGESS, JOHN S., JR.
1936. FARM PRICES OF COTTON RELATED TO ITS GRADE AND STAPLE LENGTH IN THE UNITED STATES, SEASONS 1928-29 TO 1932-33. U. S. Dept. Agr. Tech. Bull. 493, 62 pp., illus.

(9) KILLOUGH, D. T., AND McNESS, G. T.
1930. METHODS OF GINNING IN RELATION TO GRADE AND STAPLE OF COTTON. Texas Agr. Expt. Sta. Bull. 416, 32 pp., illus.

(10) LOVE, H. H.
1924. A MODIFICATION OF STUDENT'S TABLE FOR USE IN INTERPRETING EXPERIMENTAL RESULTS. Jour. Amer. Soc. Agron. 16:68-73.

(11) NICKERSON, D.
1929. A METHOD FOR DETERMINING THE COLOR OF AGRICULTURAL PRODUCTS U. S. Dept. Agr. Tech. Bull. 154, 32 pp., illus.

(12) NICKERSON, D.
1931. A COLORIMETER FOR USE WITH DISC MIXTURE. Jour. Optical Soc. Amer. 21:640-642, illus.

(13) ______
1931. COLOR MEASUREMENTS IN PSYCHOLOGICAL TERMS. Jour. Optical Soc. Amer. 21:643-650, illus.

(14) NISENGAUZ, A. D., KOKOTKIN, S. P., AND TOPOL'SKAIA, O. M.
1935. RESULTS OF A STUDY OF THE WORK OF GIN SAWS DIFFERING IN THEIR TEETH PROFILES. Uzbekistan, Trest. khlopkoochistitel' noi promyshlennosti (Cotton cleaning industry trust) Sbornik No. 4, pp.126-132 (In Russian)

(15) PEARSON, NORMA L.
1935. NEPS AND SIMILAR IMPERFECTIONS IN COTTON. U. S. Dept. Agr. Tech. Bull. 396, 18 pp., illus.

(16) SMITH, GLENN R.
1936. GIN DAMAGE OF COTTON IN RELATION TO RAINFALL. N. C. Agr. Expt. Sta. Bull. 306, 26 pp., illus.

(17) STEDRONSKY, VICTOR L., AND JOHNSON, ARVID J.
1937. CARE AND REPAIR OF COTTON GIN BRUSHES. U. S. Dept. Agr. Circ. 467, 14 pp., illus.

(18) WEBB, R. W.
1932. THE SUTER-WEBB DUPLEX COTTON FIBER SORTER AND THE RESULTING METHOD OF LENGTH-VARIABILITY MEASUREMENTS. Amer. Soc. Testing Materials Proc. v. 32, pt. 2, pp. 764-771, illus.